White Paper: All About Threads

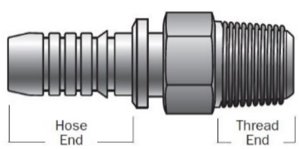
The Importance of Hydraulic Thread Identification

Garrett Bell, Key Accounts Sales Manager – Automotive Aftermarket

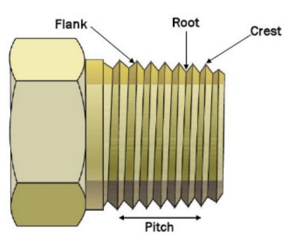
Hydraulic coupling threads are available in many different shapes, sizes, and standards. They come in either male (threads on the outside) or female (threads on the inside) and can be found on both fixed and swiveling nuts. When building or replacing hydraulic hose assemblies, proper thread identification will help guarantee your replacement hose assembly has been built with the correct couplings. Proper thread identification inside ports will also ensure you use the correct adapter or coupling, preventing the costly mistake of choosing an incorrect thread and damaging an expensive control valve or actuator. Understanding the characteristics of threads, the different standards, how to measure threads, and what thread identification tools are available will help ensure accuracy as well as efficiency.

The Anatomy of a Thread

A hydraulic coupling consists of two parts – the ferrule and the thread. The ferrule end crimps (permanent) or field attaches (reusable) on a hydraulic hose, while the threads hold the connection together, and in certain cases even provide the seal.



Merriam–Webster defines a thread as the projecting helical rib (teeth) of a screw – or in this case – a hydraulic coupling thread. There are 4 parts to a hydraulic coupling thread: the (1) crest, (2) root, (3) flank, and (4) pitch:

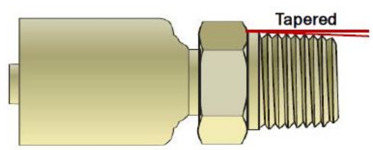


1. *Thread crests* are the top, or peak, of the projecting helical rib. Depending on the thread form, these could be a round or flat shape.
2. *Thread roots* are the bottom, or valley, of the projecting helical rib. Its shape will correspond to its crest and will be flat or rounded, depending on the thread form.
3. *Thread flanks* connect the crest and root. Flanks on a hydraulic coupling thread will either be 55 degrees or 60 degrees, depending on the thread form.
4. *Thread pitch* is the distance between the thread crests and is measured two ways, depending on the thread form – (1) the number of threads per inch (TPI) or (2) the distance between one crest to another measured in millimeters (mm).

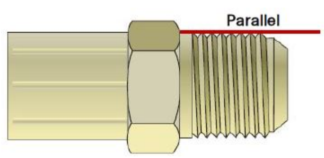
White Paper: All About Threads

Hydraulic coupling threads also come in either a 47 degree tapered or parallel (straight) profile. Knowing how to spot a tapered vs parallel thread will help you immediately narrow down the coupling options, making identifying a hydraulic coupling a faster process.

Tapered threads are designed so that when the male threads are screwed into the female threads, the two threads will wedge together and hold a connection mechanically in place. The wedging action on a hydraulic coupling can also form a thread interference seal. The diameter of a tapered thread will decrease from the bottom of the thread to the top. If you were to measure the bottom, middle, and the top of a thread, you would get three different measurements. This profile is hard to determine visually through the untrained eye but laying a straight edge along the threads can help you easily notice the taper profile, as the straight edge will lean to one direction.



Parallel (straight) threads were designed to hold the connection together, while sealing mechanically, to provide a more stress free and reliable connection. This makes parallel threads a more suitable option for hydraulic systems. Parallel threads have the same diameter over the span of the thread, so no matter which part of the thread you measure, you will get the same measurement.



Common Hydraulic Coupling Thread Standards

Hydraulic couplings come in different thread standards, and within each thread standard are different categories. These standards differ by their profile (tapered or straight), crest and root shape, flank angle, and how the major outside thread diameter (OD) and pitch are measured. The most common thread standards found on hydraulic couplings are National Pipe (NP), British Standard Pipe (BSP), Unified Thread Standard (UTS), and Metric (M).

National Pipe (NP)

National Pipe (NP) is an American thread standard commonly found on hydraulic pipe couplings in North America and is available in a tapered or straight thread profile. NP uses the Sellers thread form, meaning it has a flattened crest and root, and a flank angle of 60 degrees. The pitch is measured by counting the number of thread crests per one inch (TPI). Within NP threads are two categories found on hydraulic couplings: National Pipe Tapered Fuel (NPTF) and National Pipe Straight Mechanical (NPSM). Both are identical except for one major difference: NPTF has a tapered thread profile and NPSM has a parallel thread profile. This is important to understand because through they may thread into one another and appear to connect properly, tapered NP series will use the threads to secure the connection while making a thread interference seal, while parallel NP series will use the threads to secure the connection but seal mechanically elsewhere.

National Pipe Tapered Fuel (NTPF), also referred to as Dryseal, is based off National Pipe Tapered (NPT) that was used in hydraulic systems a long time ago. NPT and NPTF use a wedging action to hold a connection in place and/or provide a thread interference seal. The thread characteristics between NPT and NPTF are almost identical but with one difference: NPTF is a higher-quality pipe thread that is used on higher pressure hydraulic systems, while NPT is a lower-quality pipe thread that is used on lower pressure systems. The differences in the thread qualities are due to the variations in manufacturing process. NPT is manufactured using a process called “thread rolling,” where the outcome produces a lower-quality thread with a spiraling leak path. This is because thread rolling does not produce threads that allow the crest and root on the male and female to make full contact, so a leak path will always exist down the helical spiral of the thread. Due to this leak path, thread sealant is needed to ensure a seal. On the other hand, NPTF are produced using a method called “thread cutting” or “milling.” This manufacturing process results in much higher-quality threads that are cut to a shorter, exact length, which allows the crest and root on the male and female to make full contact. Therefore, there is no leak path present, and sealant is not needed (nor is thread sealant ever recommended on hydraulic systems). NPT and NPTF threads are limited on the number of times they can be reused because each time you wedge the male and female threads together, you lose more and more of the taper until it will no longer hold a connection and/or provide a seal. Male NPTF threads on hydraulic couplings will usually have a 30 degree cone seat on the face of the threads, which allows it to seal mechanically with both female NPTF and NPSM threads.

National Pipe Straight Mechanical (NPSM) is another category of NP. NPSM threads are parallel and are intended to secure the connection – rather than create the seal – and hold a seal in place. NPSM threads can be reused more often since the threads do not wedge together. NPSM threads are usually found on female hydraulic couplings and connect to male NPTF couplings that have a 30 degree cone seat on the face of the threads.

British Standard Pipe (BSP)

BSP threads are very common in Europe and Japan but are growing in popularity in North America due the increasing presence of foreign applications. The crests and roots on a BSP thread are rounded, the flank angle is 55 degrees (Whitworth thread form), and the pitch is measured by TPI. BSP threads come in two categories: British Standard Pipe Tapered (BSPT) and British Standard Pipe Parallel (BSPP).

BSP threads that are tapered are referred to as BSPT and the threads are intended to hold a connection in place mechanically and/or provide a thread interference seal. BSPT has the disadvantage of not being a reusable thread due to the wedging action that takes place between the male and female threads.

BSP threads that are parallel are referred to as BSPP. The parrel threads are intended to hold the connection together mechanically and will never provide the seal. BSPP threads provide a more stress-free and reliable connection due to the parallel thread profile, making it a more reusable thread vs its tapered counterpart. Some manufacturers will include a 30-degree cone seat on the male BSPT so it can seal with a female BSPP mechanically, but not all manufacturers offer this option.

NP/BSP Thread Misidentification

Both NP and BSP threads are very similar, but they are not interchangeable. Even though the crest and root shapes are different, and flank angle degrees are slightly different, these threads will appear identical. In certain sizes, they can even thread into each other and appear to form a good connection and/or seal. In most cases, identifying the pitch and referring to a thread identification chart will accurately identify the two from one another. But ½" and ¾" NP and BSP threads share the exact pitch and nominal thread diameter, making differentiating between the two very difficult. The best way to accurately identify NP vs BSP couplings in sizes ½" and ¾" is to verify the manufacturer's Certificate of Origin. If the application the original hose came from was manufactured in North America, chances are the threads are NP. If the application was manufactured in Europe, Japan, or China, the threads are most likely BSP.

Unified Thread Standard (UTS)

Unified Thread Standard (UTS) is commonly used on North American couplings. UTS was developed during World War 2 to address the interchangeability of military applications between the Allies. The crest and root are flat, the flank angle is 60 degrees, and the pitch is measured by TPI. UTS threads are parallel and never tapered.

UTS has different series that differ based on the pitch and the thread OD. The most common UTS series found on hydraulic couplings are Unified National Constant (UN), Unified National Fine (UNF), and Unified National Special (UNS). Thread performance requirements are taken into consideration when manufacturers choose which UTS series to use because each UTS thread series have their own advantages and disadvantages.

UN series threads have a constant pitch regardless of the major thread OD. On hydraulic couplings, the constant pitch commonly used on UN threads are 12 and 16 TPI. Flat Face O-ring (FFOR) threads, for example, have UN threads with 16 TPI on sizes ⅜", ½", and ⅝". FFOR threads that are ¾" and larger have UN threads with a TPI of 12. There are cases where the constant pitch is the same as other UTS threads, such as UNF threads with 16 TPI.

UNF series threads will have a specific TPI that varies based on the major thread OD (outside diameter) – as the diameter increases, the TPI will decrease. In certain diameters, it becomes impractical to use UN threads, so UNF threads will be more suitable because finer threads have certain advantages, such as better locking abilities, because there are more TPI.

UNS series threads will have a unique (special) thread pitch and major thread OD combinations for high-stress situations and will have more TPI than a correlating size with UNF threads, making it the strongest option of the UTS standard. UNS threads are found on two hydraulic coupling series: ⅝" FFOR and ¾" SAE 45, each with a TPI of 14.

Metric Threads

Metric threads come in both tapered and parallel thread form, though parallel is most common on hydraulic coupling threads. Metric threads will have a flank angle of 60 degrees with flat crests and roots. The difference between metric threads versus all the other thread types is the pitch. Rather than being measured using TPI, a metric thread pitch is measured using the distance between one thread crest to the next, calculated in millimeters (mm). Metric threads are common outside the United States and are found on German DIN, Komatsu, and French GAZ couplings.

BSP threads are mistakenly referred to as metric threads because both are found on non-SAE applications, but this is inaccurate because the pitch on BSP threads is measured using TPI and not in millimeters.

Measuring Thread Diameter

Thread measurements have a real and a nominal value. The real value is referred to as the major OD of the thread and is the true (real) measurement of the threads outside diameter. Nominal sizing is used for identification purposes and, aside from metric threads, will never reflect the major OD of the threads. You must know the major OD of the thread to determine its nominal size. Metric threads, however, do not have a nominal value and are identified by the major OD of the threads in millimeter (mm). The method for determining the nominal size for pipe threads differs from the method used for UTS threads.

Determining the nominal size for pipe threads is based off an outdated method. In the early days, pipe threads were measured based on the ID of the tube, which would measure its corresponding nominal size. As pipe system pressures started to increase, pipe fittings needed to be able to handle these higher pressures while keeping the thread dimensions unchanged. The solution was to use a thicker scheduled tube, which would make the inner diameter (ID) smaller but keep the OD of the threads the same. Now, to determine the nominal size for pipe threads, you would first use calipers at a 45-degree angle and measure the major OD, then subtract ¼" from the major OD and round off. Afterwards, consult with a thread identification chart, one can be found in the Gates Hydraulic and Fleet Hose catalog, and find the nearest nominal thread size. For example, a ½" male pipe thread will have a major OD of $^{27}/_{32}$". Subtracting ¼" from the major OD will give you a measurement of $^{19}/_{32}$." When you consult a thread chart, you will find that the closest nominal size is ½" (pipe threads are not available in ⅝" increments).

To determine the nominal size for a UTS thread, use calipers at a 45-degree angle and measure the OD of the threads, then reference the major OD measurements in a thread chart to find the nominal size closest to your major OD. Subtracting ¼" from the major OD is not necessary because UTS threads were developed later than pipe threads and they have always based their measurements off the major OD.

The industry standard used to notate the nominal thread OD is called a "dash size" or "dash number." Dash numbers express the nominal OD in $^{1}/_{16}$" increments. For example, a thread with a nominal OD of ⅜" would have a dash number of 06. This is because there are 6, $^{1}/_{16}$" increments (6 x $^{1}/_{16}$"), which would equal $^{6}/_{16}$". The numerator (6) would be your dash number while the denominator (16) is ignored. $^{6}/_{16}$" can be reduced down to ⅜", reflecting its nominal OD.

Dash Size	Nominal Size (In.)
-2	1/8
-4	1/4
-6	3/8
-8	1/2
-12	3/4
-16	1
-20	1-1/4
-24	1-1/2
-32	2

Thread Identification Tools and Conclusion

Knowing the different thread options and being able to properly measure the pitch and diameter are very important when identifying hydraulic couplings. Gates offers a variety of tools to help you quickly and accurately find these measurements that are crucial for proper coupling identification. The Gates North American (70270) and International (70264) Thread Identification kits allow for a quick and easy way to identify each of the thread forms. Each kit comes with color coated, fractional gauges (depending on the thread series), and each gauge will have the major OD and pitch marked. Gates also has a Pocket Thread Identification Kit (86583) that comes with a set of thread gauges, calipers, and thread identification booklet for quick references out in the field. If you need more information on certain hydraulic coupling threads, contact the Gates Product Application Engineers on the technical hotline at (303) 744–5651 or FPPASupport@gates.com.